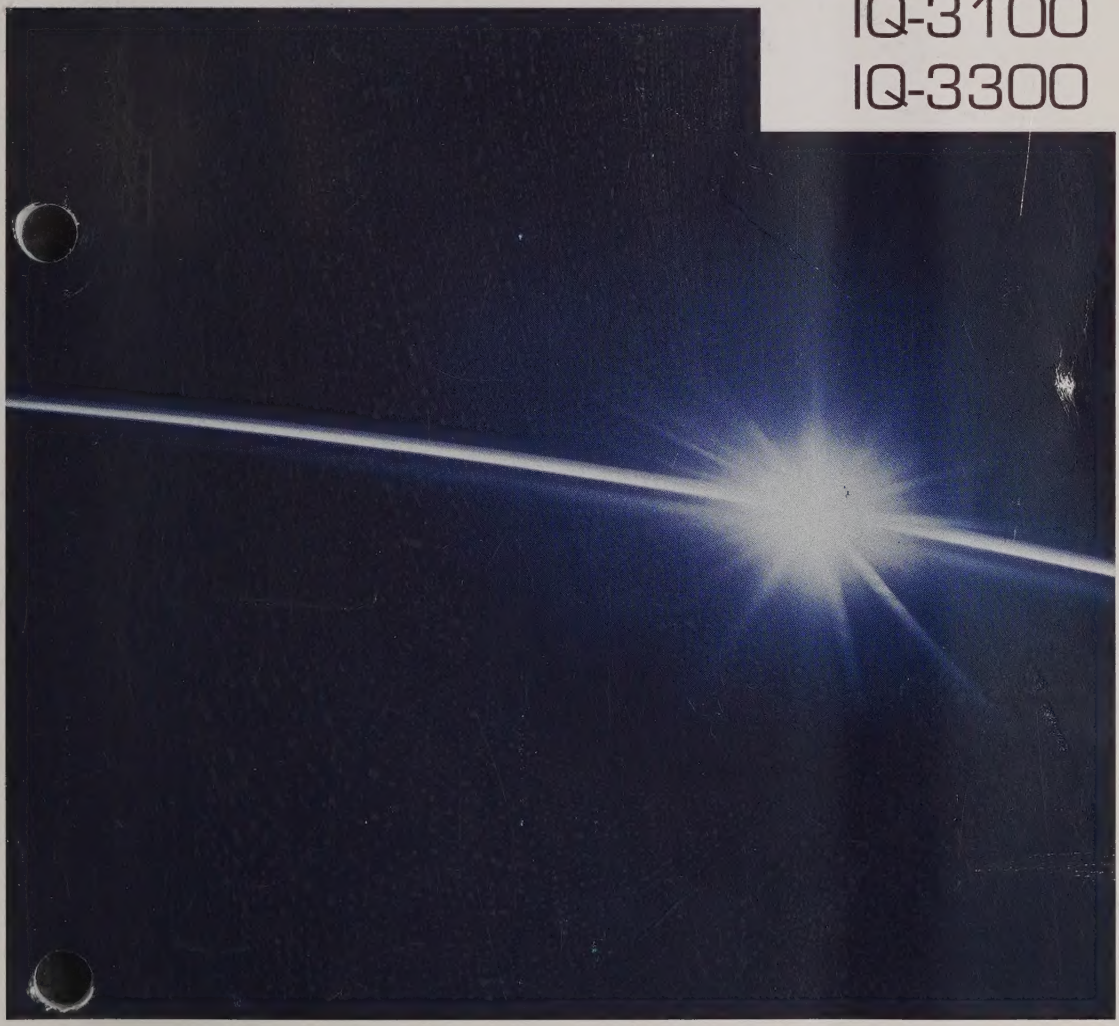
Variable Attenuator and Back Reflector

IQ-3100
IQ-3300



EXFO

IQ-3100 Variable Attenuator

IQ-3300 Variable Reflector

Instruction Manual

November 1997
P/N: MAN-108-I .1ACE

First Edition

CE

If the equipment described herein bears the CE *symbol, the said equipment complies with the European Community Directive and Standards found in the Declaration of Conformity.*

If the equipment described herein bears an **FCC** *statement, the said equipment complies with the relevant Federal Communications Commission standards.*

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CERTIFICATION INFORMATION

F.C.C. INFORMATION TO USER

This unit has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This unit generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this unit does cause harmful interference to radio or television reception, which can be determined by turning the unit off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the unit and receiver.
- Connect the unit into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

WARNING

Changes or modifications not expressly approved by EXFO Electro-Optical Engineering could void the user's authority to operate the unit.

INDEPENDENT LABORATORY TESTING

This unit has undergone extensive CE certification testing both internally, at EXFO, and externally, at an independent, qualified laboratory. All pre-qualification tests were performed at EXFO while all final tests were performed at UltraTech Engineering Labs Inc., a renowned test laboratory from Mississauga, Canada. This guarantees the unerring objectivity and authoritative compliance of all test results.

CE INFORMATION TO USER

This unit has been tested and found to comply with the limits for a Class B digital device. Please see the Declaration of Conformity.

If the unit described herein bears the CE symbol, the said unit complies with the European Community Directive and Standards found in the Declaration of Conformity.

If the unit described herein bears an **FCC** *statement, the said unit complies with the relevant Federal Communications Commission standards.*

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1 INTRODUCTION

1.1 Presentation

EXFO E. O. Engineering Inc. (EXFO) is pleased to introduce the IQ-3100 Variable Attenuator and IQ-3300 Variable Reflector modules as part of the IQ-200 Optical Test System product line.

EXFO's commitment to superior design in all its fiber-optic instrumentation is respected throughout the industry and is based on the following four goals:

- reliable and accurate performance
- simple operation
- extensive features
- dedicated interest in customer needs

The IQ-3100 Variable Attenuator and IQ-3300 Variable Reflector will provide many years of reliable operation. To fully benefit from the many features offered by the IQ-3100 and IQ-3300, it is important to read the contents of this instruction manual thoroughly.

1.2 IQ-200 Product Line

The IQ-200 product line is a modular optical test system designed for laboratory applications. Thanks to the Windows™ compatible IQ Software, the IQ-200 Optical Test System combines power, performance, flexibility with a user-friendly interface. The main components of the system are the IQ-203 Mainframe, which can house three modules, and the IQ-206 Expansion Unit, which can house six modules. It is also possible to control one or several IQ-206 Expansion Units with an IQ-206 PC Expansion Card.

For more information on the IQ-200 Optical Test System and the IQ Software, please refer to the *IQ-200 Optical Test System Instruction Manual*.

1.3 Unpacking and Inspection

The IQ-3100 and the IQ-3300 are delivered with the following standard items:

- Instruction Manual
- back-up floppy disk
- accessory kit
- Certificate of Calibration
- Declaration of Conformity

The IQ-3100 and IQ-3300 modules have been thoroughly inspected before shipment. If any damage has occurred during transportation or if any item is missing, please notify EXFO immediately.

1.4 Safety Conventions

The following conventions should be understood before operating the unit:

WARNING — Refers to a potential *personal* hazard. It requires a procedure which, if not correctly followed, may result in personal injury. Do not proceed beyond a **WARNING** unless the required conditions are fully understood and met.

CAUTION — Refers to a potential *product* hazard. It requires a procedure which, if not correctly followed, may result in component damage. Do not proceed beyond a **CAUTION** unless the required conditions are fully understood and met.

IMPORTANT — Refers to any information regarding the operation of the product which should not be overlooked.

1.5 Safety Information

Laser radiation may be encountered at the output port when an active source is connected to the IQ-3100 and IQ-3300 input ports.

WARNING

Do not install or terminate fibers while a laser source is active. Ensure that your eyes are protected at all times and never look directly into a live fiber.

1.6 Transportation and Storage

Maintain a temperature range within specifications when transporting or storing the unit. Transportation damage can occur from improper handling. The following steps are recommended to minimize the possibility of damage:

- Pack the unit in the original packing material when shipping.
- Store unit at room temperature in a clean and dry area. Avoid high humidity or large temperature fluctuations.
- Keep the unit out of direct sunlight.
- Avoid unnecessary shock and vibration.

1.7 Getting Help

If any difficulty is encountered while operating the unit, please call EXFO at one of the offices listed below. The Customer Service Group is available from 7:30 a.m. to 8:00 p.m. eastern time, Monday to Friday.

Corporate Headquarters
465 Godin Avenue
Vanier QC
G1M 3G7
Canada

1-800-663-3936 (USA and Canada)
Tel.: 1-418-683-0211
Fax: 1-418-683-2170
support@exfo.com
www.exfo.com

EXFO Europe
Centre d'Affaires-Les Metz
100, rue Albert Calmette
78353 Jouy-en-Josas, France

Tel.: 33-1-34.63.00.20
Fax: 33-1-34.65.90.93
exfoeur@ibm.net

2 PRELIMINARY INFORMATION

2.1 General Description

The IQ-3100 Variable Attenuator offers impressive resolution and linearity, low back reflection, and repeatability over a wide dynamic range. This performance is achieved through the combination of precision optical filtering techniques, an accurate positioning motor, and EXFO's computer-assisted calibration process. The IQ-3100 is particularly well suited for the most demanding laboratory and manufacturing qualification applications.

Applications for the IQ-3100 include

- precise variable output power levels over a large dynamic range when used with an optical source (e.g. IQ-2100)
- R&D laboratory measurements
- manufacturing laboratory measurements
- power meter calibration and linearity verification
- fiber-optic system or component testing and acceptance
- simulation of fiber-optic system loss
- optical margin analysis

The IQ-3300 Variable Reflector module is used to generate a calibrated optical reflection back into the fiber connected to the input port. This module will help to determine a system's or component's sensitivity to reflected power.

Applications for the IQ-3300 include

- R&D laboratory measurements
- manufacturing laboratory measurements
- bit error rate vs. return loss characterization
- source power and spectral stability measurements
- system noise performance tests

- distortion tests
- return loss meter certification

Both modules are designed for laboratory and industry applications using the IQ-200 Optical Test System.

The IQ-3100 and IQ-3300 support both local and remote control. Local control is via the Windows compatible software preinstalled on the IQ-203 or installed on a host PC when using the IQ-206 and PC expansion card. This software provides both direct manual control and automatic programmable operation.

Remote control is accomplished through one of these four ways:

- a GPIB interface
- an RS-232 external interface
- Windows OLE (Object Linking and Embedding) automation
- a Windows DDE (Dynamic Data Exchange) communication channel

Please refer to the IQ-200 GPIB and Application Development Guide for detailed information about remote control of the IQ components.

The IQ-3100 software provides both direct manual control and automatic programmable operation. Programmable operation allows the user to define and execute attenuation scanning. Up to 100 steps may be programmed.

The IQ-3300 software provides a user-friendly programmable mode. Using this feature, it will change the reflection up to 99 times, wait for up to 59 hours, 59 minutes, and 59 seconds between each change.

The product nameplate is located on a side panel near the rear of the module.

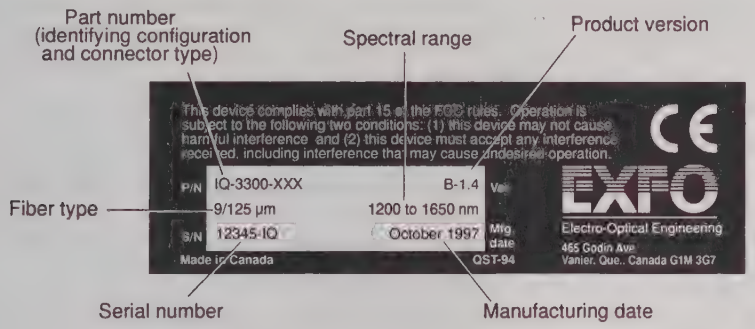

Figure 2-1 Module Nameplate

***Note**: The information found on the nameplate will differ according to the module configuration.*

2.2 Front Panel Description

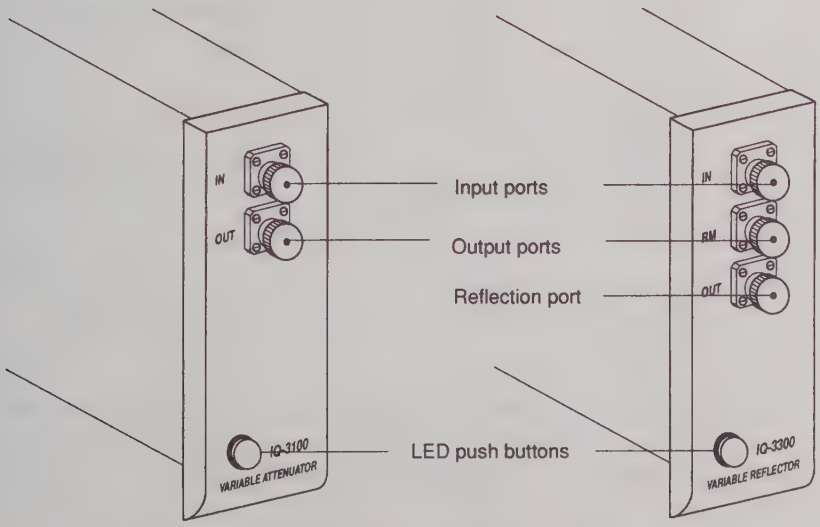

Figure 2-2 Variable Attenuator and Variable Reflector Modules

***Note**: Actual port(s) may differ from those depicted in the illustration.*

2.2.1 Optical Ports

The input, output, and reflection monitor (RM) ports are located on the front panel. Depending on the connector options selected, the optical ports may differ from those depicted in Figure 2-2. The input, output, and reflection monitor (RM) connections are clearly labeled.

2.2.2 LED Push Button

The LED push button on the front panel has the following three functions:

- When system is powered ON, the LED will illuminate.
- Pressing the LED push button activates the main window.
- Pressing the LED push button when the main window is open activates the monitor window.

***Note:** The monitor window is a compact window displaying basic data and is fully explained in Section 3.2, Monitor Window.*

2.3 IQ-3100 Attenuation Definition

The significance of the attenuation value displayed by an optical attenuator may differ from one manufacturer to another. At EXFO, for example, an IQ-3100 attenuation would be measured the following way:

- Use two fiber-optic test jumpers and a bulkhead connector to connect an IQ-1100 Power Meter and an IQ-2100 Light Source together.
- Reference the power meter.
- Replace the bulkhead connector with the IQ-3100. The attenuation displayed by the power meter will be the same as the attenuation setting of the IQ-3100, within the absolute accuracy of the attenuator.

Therefore, the attenuation displayed by the IQ-3100 is the actual loss or attenuation between the input and output ports including the attenuator's internal connectors.

2.3.1 IQ-3300 Theory of Operation

Figure 2-3 illustrates a block diagram of the IQ-3300. The variable reflector is designed around a variable attenuator/mirror assembly coupled to an input port, output port, and a monitoring port. Optical energy entering the input port is coupled to the attenuator/mirror assembly and to the output port. There is less than 5 dB loss between the input and output ports.

Optical energy passes through the attenuator, is reflected by the mirror, returns through the attenuator, and is coupled back to the input port and reflection monitor port. The intensity of the reflected optical energy is determined by the attenuation introduced by the internal variable attenuator.

The variable reflector is calibrated to provide between -15.00 dB and -55.0 dB reflection.

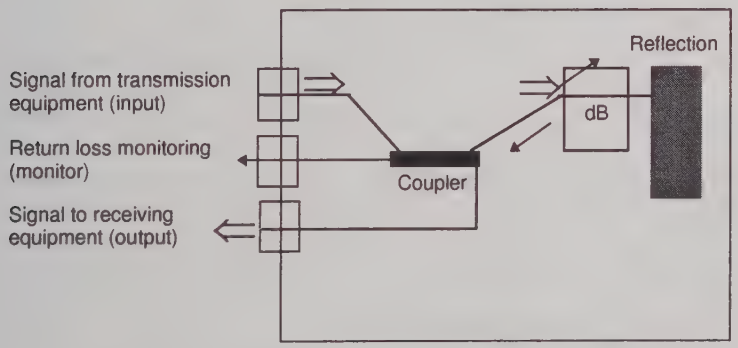

Figure 2-3 Maximum Return Loss and Optical Insertion Loss

2.4 Module Insertion

CAUTION

Never insert or remove any module while the IQ-203/IQ-206 is powered on. This will result in damage to the module and to the IQ-203/IQ-206.

To insert the module

1. Power off the IQ-203/IQ-206.
2. Insert the module into any available slot. The IQ-203/IQ-206 will automatically recognize the module no matter what slot it is inserted in.

IMPORTANT

Be sure to insert the module all the way to the back of the IQ-203/IQ-206 so as to ensure that the backplane connectors are properly mated. The module is correctly inserted when the module front panel is flush with the IQ-203/IQ-206 front panel.

2.5 Optical Connections

IMPORTANT

Always clean fiber end prior to insertion into the port as explained below.

The fiber-optic cable end should be cleaned at all times to ensure optimum performance and to avoid erroneous readings. To clean the fiber end

1. Gently wipe the end with a lint-free swab dipped in isopropyl alcohol.
2. Dry using clean compressed air.

To connect the fiber-optic cable to the port

1. Ensure the connector is dry.

2. Align the connector and port to avoid the fiber end touching the outside of the port or rubbing against other surfaces.

3. Do not overtighten.

***Note**: The IQ-3300 uses APC (angled physical contact) connectors.*

2.6 Module Removal

CAUTION

Never insert or remove any module while the IQ-203/IQ-206 is powered on. This will result in damage to the module and to the IQ-203/IQ-206.

Depending on the locking system with which the module is designed, there are two ways to remove an IQ module from the IQ-203 Mainframe/IQ-206 Expansion Unit:

1. With the IQ-203 Mainframe/IQ-206 Expansion Unit powered off, place fingers under the front panel of the module and firmly pull module outward.

2. Put one of the supplied protective covers over the empty slot to prevent dust from entering the module housing.

Or:

1. As shown in the following figure, with the IQ-203 Mainframe/IQ-206 Expansion Unit powered off, push up the locking mechanism under the front panel of the module.

2. Pull out the module.

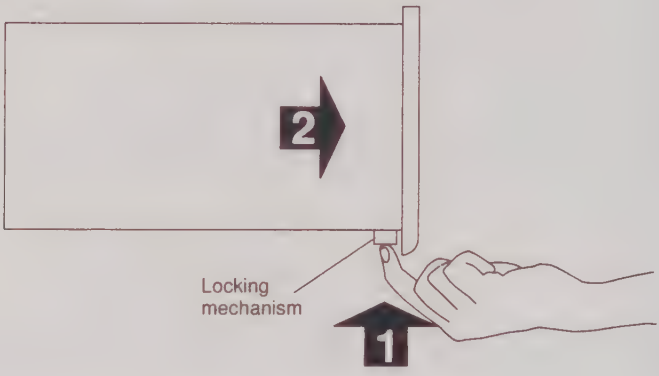

Figure 2-4 Removing an IQ Module

3. Put one of the supplied protective covers over the empty slot to prevent dust from entering the module housing.

2.7 Loading the Application

The many features of the variable reflector are controlled using the Windows-compatible IQ Software. Please refer to the *IQ-200 Optical Test System Instruction Manual* for information regarding the IQ-200 Optical Test System.

There are two ways to load the application software.

- Push the LED push button on the module front panel.
- Double-click on the corresponding icon in the IQ-200 Optical Test System main window.

Once the application software is loaded, the main window opens. The main window contains all necessary commands to control the module. For more information on the main window, see Section 3.1, *Main Window Description*, on page 3-1.

2.8 Exiting the Application

Closing any application software that is not in use is a good way to free system memory. The application software can be closed either from the main window or from the monitor window.

2.8.1 From the Main Window

There are three ways to exit the application software from the main window:

- Click on ☒ (in the upper right corner of the main window).
- Choose **Exit** from the **File** menu.
- Click on the module icon (in the top left corner of the main window) and select **Close**.

2.8.2 From the Monitor Window

To exit the application software from the monitor window, click on ☒ (in the upper right corner of the monitor window).

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3 OPERATION

3.1 Main Window Description

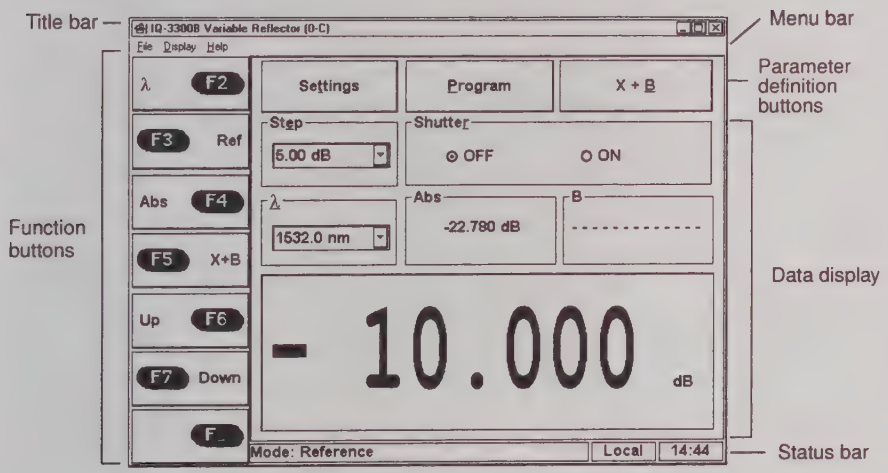

Figure 3-1 IQ-3300 Main Window

The main window, shown in Figure 3-1, can be broken down into five sections:

- title bar and menu bar
- function buttons
- parameter definition buttons
- data display
- status bar

3.1.1 Title Bar and Menu Bar

The title bar and the menu bar are at the top of the main window (refer to Figure 3-1). The title bar indicates the module in use. The menu bar contains three pull down menus that are explained in the following table.

Menu	Option	Function
File	Open config...	Opens to a previously saved configuration.
	Save config...	Saves the current configuration.
	Exit	Closes the application.
Display	Monitor	Opens the monitor window which displays basic power meter data (for detailed information on the monitor window, see Section 3.2, *Monitor Window*, on page 3-6).
Help	Online Manual	Opens the application Help file, which contains the text of the present instruction manual.
	About...	Opens a window which provides the following information: • software version • technical assistance telephone numbers, e-mail and web-site addresses • available IQ-203 system memory (RAM) • remaining hard disk drive storage space

Table 3-1 Main Window Menus

3.1.2 Function Buttons

The function buttons, located on the left side of the main window, are used for immediate control of the module. Section 3-2, *Function Buttons*, on page 3-3, provides a quick reference guide to these controls.

Button	Description
λ F2	Switches to the next wavelength as defined by the contents of the λ list box (see Section 3.6, *Setting Wavelength*, on page 3-18).
F3 Ref	Switches to **Reference** attenuation/reflection mode (see Section 3.4.2, *Reference Mode*, on page 3-11).
Abs F4	Switches to **Absolute** attenuation/reflection mode (see Section 3.4.1, *Absolute Mode*, on page 3-10).
F5 X+B	Switches to **X+B** attenuation/reflection mode (see Section 3.4.3, *X+B Mode*, on page 3-13).
Up F6	Increases the attenuation/reflection (larger negative number) by the amount indicated in the **Step** list box (see Section 3.5, *Setting Attenuation and Reflection*, on page 3-16).
F7 Down	Decreases the attenuation/reflection (smaller negative number) by the amount indicated in the **Step** list box (see Section 3.5, *Setting Attenuation and Reflection*, on page 3-16).
F_	Transfers control between software function buttons and IQ-203 front panel hardware function keys (refer to *IQ-200 Optical Test System Instruction Manual*). ***Note**: When software function buttons are disabled, they appear dark gray.*

Table 3-2 Function Buttons

***Note**: These function buttons can be accessed, while in window monitor mode, by positioning the cursor inside the monitor window and clicking the right mouse button. The function button keypad will appear to the left of the monitor window.*

3.1.3 Parameter Definition Buttons

Choosing any of the parameter definition buttons opens a window permitting the definition and customization of various modules' operating parameters. Table 3-3 describes the function of these buttons.

Button	Description
Settings...	Opens the **Settings** window where the contents of the λ and **Step** list boxes may be customized (see Section 3.3, *Customizing Wavelength and Step Size List Boxes*, on page 3-7).
Program...	Opens the **Program settings** window where program mode parameters may be defined (see Section 3.7, *Program Mode*, on page 3-19).
X + B...	Opens the **B Setting** window where a B value for each available wavelength may be defined (see Section 3.4.3, *X+B Mode*, on page 3-13).

Table 3-3 Parameter Definition Buttons

3.1.4 Data Display

The data display shown in Figure 3-1 contains list boxes, edit boxes, and display boxes. A description of the sections of the data display is provided in Table 3-4.

Box	Description
Step	Displays the currently selected step size. Open the list box to select a different step size.
λ	Displays the currently selected wavelength. Open the list box to select a different wavelength.
Attenuation (IQ-3100 only)	Displays absolute attenuation in **Absolute** mode. Displays relative attenuation in **Reference** mode. Displays X + B attenuation in **X + B** mode. Edit the displayed value to change the attenuation setting.
Reflection (IQ-3300 only)	Displays the absolute reflection in **Absolute** mode. Displays relative reflection in **Reference** mode. Displays X+B reflection in **X+B** mode. Edit the displayed value to change the reflection setting.
Shutter	Select the **ON** or **OFF** radio button to activate or deactivate the shutter.
Abs Value	Displays the reference attenuation reflection plus the attenuation displayed in the Attenuation box when the IQ-3100 is in **Reference** mode. Displays the absolute reflection setting when the IQ-3300 is in relative display mode.
B Value	Displays the B value when in **X+B** mode.

Table 3-4 Data Boxes

3.1.5 Status Bar

On the status bar, you find the inscription Local, Remote, or Lockout, which indicate if the module is controlled locally or remotely. The table below explains the meaning of these inscriptions. For more information on how to control the different IQ modules remotely, refer to the *GPIB and Application Development Guide*. Finally, the status bar also displays the time.

Indication	Meaning
Local	The unit is controlled locally.
Remote	The unit is controlled remotely but local commands can still be used.
Lockout	The unit is exclusively controlled remotely.

Table 3-5 Module Control Status

3.2 Monitor Window

The monitor window displays basic variable attenuator/reflector data. Using the monitor window in conjunction with other IQ monitor windows allows the user to create an integrated data display screen (for further information, refer to the *IQ-200 Optical Test System Instruction Manual*). The size and position of the monitor window can be adjusted.

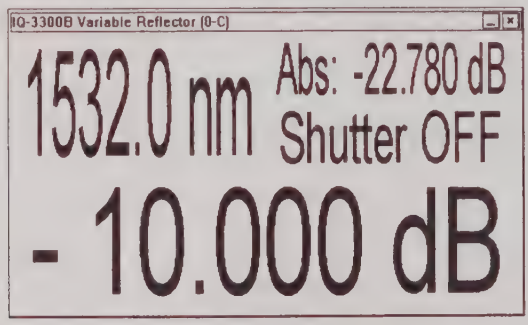

Figure 3-2 Monitor Window

3.2.1 Opening the Monitor Window

There are three ways to open the monitor window:

- In the main window, choose **Monitor** from the **Display** menu.
- In the main window, click on ▁ (in the upper right corner).
- Push the LED push button (on the front panel of the module).

3.2.2 Closing the Monitor Window

There are two ways to close the monitor window and return to the main window:

- Double-click anywhere in the monitor window.
- Push the LED push button (on the front panel of the module).

***Note**: The function buttons can be accessed while in monitor window mode by positioning the cursor inside the monitor window and clicking the right mouse button. The function button keypad will appear to the left of the monitor window.*

3.3 Customizing Wavelength and Step Size List Boxes

The contents of the λ and **Step** list boxes may be customized from the **Settings** window (shown in Figure 3-3). The values contained in these boxes determine which settings are directly available during operation. Up to 100 values may be defined in each box.

- The λ list box contains the available wavelengths.
- The **Step** list box contains the available reflection step sizes.

***Note**: Step size determines how much the attenuation will change when choosing the* **Up** *or* **Down** *buttons.*

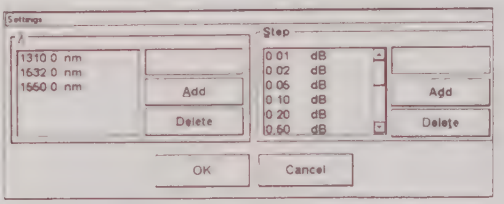

Figure 3-3 Settings Window

Both list boxes can be customized to suit specific user requirements. Choose the **Settings** button to open the **Settings** window. The **Settings** window is subdivided into two independent sections, λ and **Step**.

To add a value to the λ list box

1. If the **Settings** window is not open, choose the **Settings** button.
2. Double-click on the edit box above the **Add** button.
3. Enter the wavelength value to be added.

***Note**: For a singlemode reflector, wavelengths between 1200.0 nm and 1650.0 nm (at 0.1 nm resolution) may be entered.*

4. Choose the **Add** button to confirm the new wavelength.

➤ ***Tip**: When using the optional keyboard, pressing the <Enter> key has the same effect as choosing* **Add.**

5. Once all values have been added, choose the **OK** button to close the **Settings** window.

To delete a value from the λ list box

1. If the **Settings** window is not open, choose the **Settings** button.
2. Highlight the wavelength to be deleted.

3. Choose the **Delete** button to confirm the deletion.

4. Choose the **OK** button to close the **Settings** window.

***Note**: To close the* **Settings** *window without recording the current changes, choose the* **Cancel** *button.*

To add a value to the **Step** list box

1. If the **Settings** window is not open, choose the **Settings** button.

2. Double-click on the edit box above the **Add** button.

3. Enter the step size to be added.

***Note**: Step sizes between 0.005 dB (0.01 dB for multimode units) and 100.000 dB can be entered. Although 100.000 dB can be entered as a step size, the maximum attenuation step size that can be introduced is limited by minimum insertion loss and maximum attenuation. Since both these values are a function of wavelength, the maximum usable step size is also a function of wavelength.*

4. Confirm the new step size value by choosing the **Add** button.

5. When all values have been added, close the **Settings** window by choosing the **OK** button.

To delete a value from the **Step** list box

1. If the **Settings** window is not open, choose the **Settings** button.

2. Highlight the step size to be deleted.

3. Confirm the deletion by choosing the **Delete** button.

4. Close the **Settings** window by choosing the **OK** button.

3.4 Display Modes

The active display mode determines the significance of the value displayed in the **Attenuation** or **Reflection** box. The **Attenuation** box displays

- absolute attenuation in absolute mode
- relative attenuation in reference mode
- X+B attenuation in X+B mode

The **Reflection** box displays

- absolute reflection in absolute mode
- relative reflection in reference mode
- X+B reflection in X+B mode

***Note**: The active display mode is always indicated in the status bar at the bottom of the main window.*

The three display modes each have their advantages and are explained in the following sections.

3.4.1 Absolute Mode

By default, absolute mode is selected upon initial activation. When in absolute mode, the absolute attenuation or reflection introduced by the module is displayed in the attenuation or reflection box.

Figure 3-4 illustrates an example where a 22.780 dB loss is introduced at the 1532-nm calibrated wavelength. When in Absolute mode, a dashed line is displayed in both the **Abs** and **B** boxes. The **Status** bar displays **Mode: Absolute.**

***Note**: For the IQ-3100, the total or absolute attenuation referred to in this manual is the actual optical insertion loss between the input and output ports, including the connectors.*

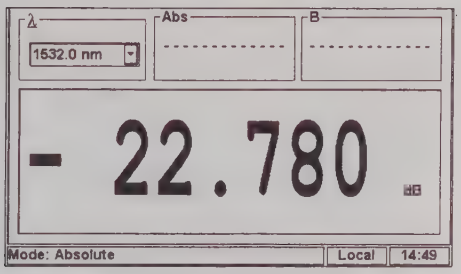

Figure 3-4 IQ-3300 - Absolute Mode

Choose the **Abs** button at any time to enable absolute mode.

3.4.2 Reference Mode

IQ-3100. When in reference mode, the value displayed in the **Attenuation** box is the attenuation, relative to a defined reference value. Any value within the attenuation range of the IQ-3100 may be selected as the reference.

IQ-3300. When in reference mode, the value displayed in the **Reflection** box is the reflection, relative to a defined reference value. Any value within the reflection range of the IQ-3300 may be selected as the reference.

When reference mode is enabled (choose **Ref**) the following occurs:

- Current absolute attenuation/reflection setting becomes the reference value.
- Reference value is displayed in the **Abs** box.
- **0.000 dB** (relative attenuation/reflection) is displayed in the **Attenuation/ Reflection** box.

Figure 3-5 illustrates an example where the reference mode was enabled with the reflection set to -22.790 dB. A dashed line is displayed in the **B** box.

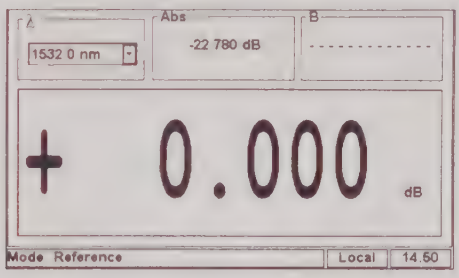

Figure 3-5 IQ-3300 - Reference Mode

***Note**: When in reference mode, the absolute attenuation/reflection is always displayed in the **Abs** box.*

To use reference mode

1. Ensure that the display is first in absolute mode (choose **Abs**).

2. Select the appropriate wavelength by choosing or opening the λ list box. For additional information, see Section 3.6, *Setting Wavelength*, on page 3-18.

3. Set the attenuation/reflection to the desired reference value. For additional information, see Section 3.5, *Setting Attenuation and Reflection*, on page 3-16.

4. Choose the **Ref** button. The display will switch to reference mode.

➤ ***Tip**: Choosing **Ref**, with the reference mode already active, will reset the reference value to the current absolute attenuation/reflection setting.*

3.4.3 X+B Mode

As the name implies, an X+B reflection is the sum of two components, X and B. To understand and effectively use the X+B mode, it is important to keep in mind that

- X is the actual physical attenuation/reflection introduced by the unit; and
- B is some offset value.

The X+B mode allows you to display attenuation/reflection readings as any value between - 99.999 dB and 99.999 dB (or a power value in dBm).

Before enabling the X+B, mode it is necessary to define the appropriate B value for the operating wavelength. A different B value can be associated to each wavelength in the λ list box. The B value may be used to compensate for losses along the connecting fibers or for losses to display the reflection as a power value.

IQ-3100. An optical light source with a power output of -14 dBm at 1310 nm is connected to a variable attenuator. Because of internal losses, the minimum insertion loss of the IQ-3100 at 1310 nm is typically 2 dB. This means that the maximum optical power available at the output port of the attenuator is -16 dBm (-14 + -2). If we now set B to -14 dBm, X+B will be displaying the optical power level at the output port of the attenuator.

Using this setup (i.e. light source, variable attenuator, and an accurately determined B value), we have created a precision variable light source with a dynamic range of nearly 100 dB.

IQ-3300. To display the reflection as a power value, an accurate B value must be calculated. Connect a power meter to the monitor port. With a source connected to the input port, measure the absolute power at the monitor port. The B value will equal the difference between the setting (e.g. -22.00 dB) and the power meter reading (e.g. -26.00 dBm). In this example, B= -26– (-22)= -4. Setting B=-4 dBm will cause the IQ-3300 to display the reflection as an absolute power value.

To define a B value for a specific wavelength

1. Choose the **X + B...** button. This opens the **B Settings** window shown in Figure 3-6.

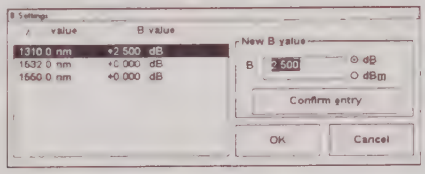

Figure 3-6 B Settings Window

2. Highlight the appropriate λ **value/B value** line.

3. Double-click on the **New B value** edit box.

4. Enter the numeric B value.

***Note**: B values between -99.999 and 99.999 may be entered.*

5. Select the **dB** or **dBm** radio button. This determines whether the B and X+B values are displayed in dB or dBm.

- Select **dB** when X+B will represent a system loss.
- Select **dBm** when X+B will represent a power level.

6. Choose the **Confirm entry** button.

7. Choose the **OK** button to close the **B Settings** window.

***Note**: To close the **B Settings** window without recording the current changes, choose the **Cancel** button.*

To use X+B mode

1. Ensure that the display is first in **Absolute** mode (choose **Abs**).

2. Select the appropriate wavelength by choosing **F2** or opening the list box. For additional information, see Section 3.6, *Setting Wavelength*, on page 3-18.

3. Open the **B settings** window (choose **X + B...**) to ensure that the B value is correct. If the value is correct, close the **B settings** window; if not, refer to the previous procedure to define a B value for a specific wavelength.

4. Choose the **F5** button. The display will switch to X+B mode.

***Note**: The B value can be modified while the X+B mode is active.*

Figure 3-7 illustrates the main window in X+B mode with the B value units set to dBm. In this figure

X = -22.780 dB and B = 0.000 dB

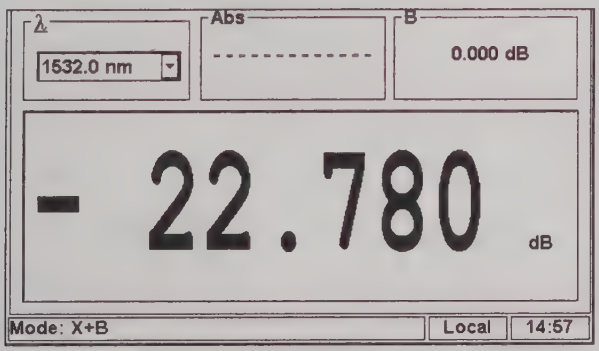

Figure 3-7 IQ-3300 - X+B Mode

3.5 Setting Attenuation and Reflection

There are two methods for changing the attenuation setting:

- Use the **Up** or **Down** buttons
- Directly edit the displayed attenuation/reflection

***Note**: Minimum insertion loss and maximum attenuation/reflection settings are wavelength dependent.*

IQ-3100. Optical attenuation, between minimum insertion loss and 100.000 dB (function of wavelength) at 0.005 dB resolution (0.01 dB for multimode modules), can be introduced by the IQ-3100.

Although EXFO guarantees that the minimum insertion loss is below a specified value (refer to specification sheet), it may vary slightly from one wavelength to another and from one IQ-3100 to another.

IQ-3300. Calibrated optical reflection between -15.00 dB and -55.00 dB at 0.01 dB resolution can be introduced by the IQ-3300. The IQ-3300 will allow the user to set values outside this range; however, the accuracy of these values cannot be guaranteed.

➤ ***Tip**: An efficient way of determining the maximum attenuation/reflection at a particular wavelength*

1. *Switch to* **Absolute** *mode.*
2. *Edit the attenuation/reflection box value to 0.000 dB.*
3. *The attenuator/reflector will reposition to the maximum setting.*
4. *Changing the setting using* **On** *or* **Off** *permits incremental changes in attenuation/reflection, while editing allows the user to quickly and precisely set the attenuation/reflection to any specific value.*

3.5.1 Using the Function Buttons

The operating software offers a wide selection of programmed step sizes. The default step sizes can be edited, and new values can be added at any time. For information on how to customize the contents of the **Step** list box, see Section 3.3, *Customizing Wavelength and Step Size List Boxes*, on page 3-7.

➤ ***Tip**: Selecting a larger step size allows for faster attenuation/reflection scanning.*

When the variable attenuator/reflector is first activated, the minimum step size is selected.

3.5.2 Selecting Step Size

1. From the main window, open the **Step** list box (shown in Figure 3-8).

2. Click on the desired value.

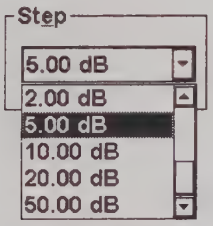

Figure 3-8 Selecting Step Size

3.5.3 Editing the Attenuation/Reflection Value

Directly editing the value displayed in the attenuation/reflection box is an efficient way of setting the attenuation/reflection to any specific value. Regardless of step size, the attenuator/reflector will reposition to the new value.

To set the attenuation/reflection by editing the displayed value

1. Double-click on the attenuation/reflection box. For aid in locating the reflection box, see Section 3.1, *Main Window Description*, on page 3-1.

2. Enter the new attenuation/reflection value.

3.6 Setting Wavelength

For accurate optical attenuation/reflection, it is essential that the attenuator/reflector wavelength be set as close as possible to the wavelength of the optical source.

IQ-3100. The variable attenuator provides calibrated optical attenuation at 0.1 nm resolution over a wide range; 1200 nm to 1650 nm for singlemode modules and 700 nm to 1350 nm for multimode modules.

IQ-3300. The variable reflector provides calibrated optical reflection at 0.1 nm resolution over a wide range; 1200 nm to 1650 nm for singlemode modules. The operating wavelength can be set in two ways:

- Use the **F2** button.
- Select a wavelength from the λ list box.

In both cases, the values contained in the λ list box determine which wavelengths may be selected. To find out how to add or delete values, see Section 3.3, *Customizing Wavelength and Step Size List Boxes*, on page 3-7.

***Note**: When switching to a new wavelength, the attenuator/reflector will reposition and will keep the same attenuation/reflection setting for the new wavelength.*

3.6.1 Selecting from the List Box

To change wavelength by selecting from the list box

1. From the main window, open the λ list box (shown in Figure 3-9).
2. Click on the desired value.

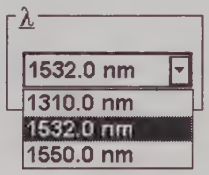

Figure 3-9 Selecting Wavelength

3.7 Program Mode

The IQ-3100 and IQ-3300 can be programmed for automatic operation. The program permits up to 100 attenuation/reflection steps with a maximum time interval of 99 hours, 59 minutes, and 59 seconds between each step. The attenuation/reflection and time interval can be defined for each program step.

3.7.1 Defining a Program

The programs are defined using the **Program settings** window. In the **Program settings** window, the attenuation/reflection setting and step duration parameters are defined for each program step. Programs are defined using absolute attenuation/reflection values. The IQ-3100 and IQ-3300 program principle is illustrated by two example programs in Table 3-6. The example programs contain three steps.

Step	Duration	Attenuation (IQ-3100)	Reflection (IQ-3300)
1	10 seconds	2.500 dB	20.000 dB
2	1 minute	5.000 dB	30.000 dB
3	1 hour	4.000 dB	40.000 dB

Table 3-6 Example Program Parameters

Referring to the example programs shown above, in the case of the IQ-3100, the incoming signal is first attenuated by 2.500 dB for 10 seconds, then by 5.000 dB for 1 minute, and finally by 4.000 dB for 1 hour.

In the case of the IQ-3300, 20.000 dB is first reflected off the original signal for 10 seconds, then 30.000 dB off the original signal for 1 minute, and finally 40.000 dB off the original signal for 1 hour.

The procedure is the same to define an attenuation program (IQ-3100) or a reflection program (IQ-3300).

1. From the main window, choose **Program**. This opens the **Program control** window.

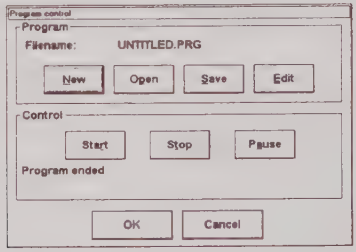

Figure 3-10 Program Control Window

2. Choose **New**. The **Program settings** window opens.

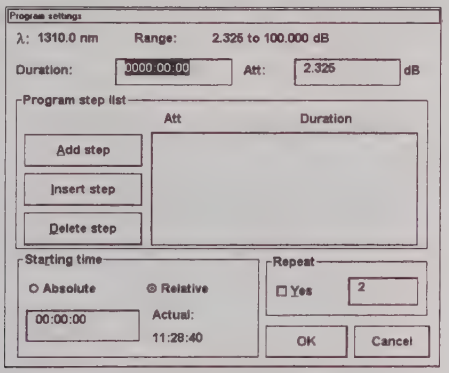

Figure 3-11 IQ-3100 Program Settings Window

3. Double-click on the **Duration:** edit box. Enter the duration for the first step (00 hours, 00 minutes, 10 seconds).

4. Double-click on the **Att:** (IQ-3100) or **Refl:** (IQ-3300) edit box. Enter the desired value.

5. Choose **Add step**. The program step will be added to the **Program step list** box.

6. Repeat steps 3, 4, and 5 for every step you want to add to the program.

***Note**: A maximum of 100 program steps may be defined.*

7. Select the appropriate **Starting time** radio button.

   - Select **Absolute** where the program is to start running at a specified time (24 hour format, e.g. 18:06:00).
   - Select **Relative** when the program is to start running after a specified time interval (e.g. 00:10:00, the program will start running 10 minutes after choosing the **Go** button).

8. Double-click on the **Starting time** edit box and enter a value. The format for the time value is HH:MM:SS.

9. Click on the **Repeat** check box if you want the program to loop. When repeat is selected, the value displayed in the adjacent edit box determines the number of program loops. Edit the number of loops as needed.

10. Choose **OK** to confirm program parameters and close the **Program settings** window.

***Note**: To close the* **Program settings** *window without recording the current changes, choose the* **Cancel** *button.*

3.7.2 Saving a Program

Attenuation and reflection programs can be saved to be recalled later.

1. Define a program as explained in Section 3.7.1, *Defining a Program*, on page 3-19.

2. Once all program parameters are defined, choose **OK** to confirm program parameters and return to the **Program control** window.

3. From the **Program control** window, choose the **Save** button.

4. Enter a file name and select the path where you want the file to be saved.

5. Choose **Save**.

3.7.3 Program Execution

1. Select the appropriate wavelength.

2. From the main window, choose **Program**. This opens the **Program control** window as shown in Figure 3-10.

   - Choose **New** to create a new program (see the procedure in Section 3.7.1, *Defining a Program*, on page 3-19); or
   - Choose **Open** to open a previously saved program.

3. If you need to edit the program or check the program parameters, choose **Edit** from the **Program control** window (see Section 3.7.4, *Program Editing*, on page 3-23).

4. To start program execution, choose **Go** from the **Program control** window.

   - Program status is always displayed at the bottom of the main window.
   - Program execution can be paused at any time by choosing **Pause** from the **Program control** window. To resume execution choose **Go**.
   - Program execution can be terminated at any time by choosing **Stop** from the **Program control** window.

3.7.4 Program Editing

The program steps cannot be edited directly. You must first delete the erroneous step and insert a new one in its place. Program step deletion and insertion is accomplished in the **Program settings** window. To access the **Program settings** window, from the main window choose **Program**, then in the **Program control** window choose **Edit**.

To delete a program step

1. With the **Program settings** window displayed, highlight the step to be deleted.

2. Choose the **Delete step** button. The program step will be deleted.

3. Choose **OK** to confirm the deletion and to close the **Program settings** window.

To insert a program step

1. With the **Program settings** window displayed, highlight the step where the new line is to be inserted.

2. Enter the duration and attenuation/reflection values in the appropriate edit boxes.

3. Choose the **Insert step** button. The new program step will be inserted above the highlighted line.

4. Choose **OK** to confirm the changes and to close the **Program settings** window.

3.8 Shutter Operation

The optical shutter (Figure 3-12) is an electro-mechanical device which, when activated from the main window, blocks light transmission/reflection generation.

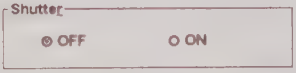

Figure 3-12 Shutter Controls

- Click on the **ON** radio button to block light transmission/internal reflection.
- Click on the **OFF** radio button to enable light transmission/internal reflection.

***Note**: When the shutter is on <55 dB, reflection is generated by the IQ-3300.*

4 SUGGESTED APPLICATIONS

4.1 IQ-3100 - Source Spectral Tuning

The attenuation introduced by the IQ-3100 is a function of the wavelength of the input optical energy. The wavelength of an optical source varies over time and slightly from one source to another. Therefore, to ensure optimal attenuator performance, it is important that the attenuator wavelength be set as near as possible to the source wavelength. The high resolution of the IQ-3100 allows the user to accurately determine the source wavelength and ensures that the IQ-3100 provides accurate attenuation values.

To accurately determine the source wavelength

1. Connect the source (e.g. IQ-2100), the IQ-3100, and power meter (e.g. IQ-1100) using appropriate test jumpers as shown in Figure 5-1.

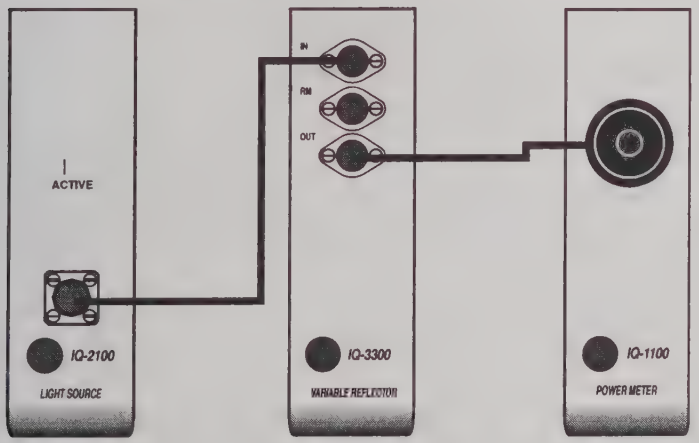

Figure 4-1 Spectral Tuning Setup

2. Set the attenuator and power meter to the approximate source wavelength (e.g. 1550 nm). See Section 3.6, *Setting Wavelength*, on page 3-18.

3. Set the IQ-3100 to minimum insertion loss. See Section 3.5, *Setting Attenuation and Reflection*, on page 3-16.

4. Reference the power meter to zero (refer to the power meter instruction manual) and switch the IQ-3100 to Reference mode (choose **Ref**). The power meter and attenuator will both display 0.0 dB.

5. Set the relative attenuation to a value where the power meter is still known to have a linear response. With an IQ-2100 source and an InGaAs detector, -60 dB is a good value. The value displayed by the power meter will not likely equal -60.0 dB. A difference in readings between the attenuator and power meter indicates that the central wavelength of the source output is not 1550 nm.

6. Adjust the IQ-3100 wavelength until the expected attenuation (-60.0 dB) is displayed on the power meter. See Section 3.6, *Setting Wavelength*, on page 3-18.

7. The actual source wavelength has now been determined and the attenuator can be used with optimum accuracy.

***Note**: The above procedure assumes the following conditions:*

- *All optical connections are clean and properly mated.*
- *The IQ-3100 and IQ-1100 have valid calibrations (EXFO recommends once a year).*
- *The operating environment is within the specified range of all instruments.*

4.2 IQ-3100 - Measuring the Multimode Insertion Loss

Often, when using a connectorized multimode source (mostly LED sources), part of the optical energy is transmitted into the fiber cladding. These cladding modes attenuate rapidly (refer to Figure 5-2), but will affect power meter readings if the source is connected using only a short jumper, as would be the case when taking a reference before measuring insertion loss.

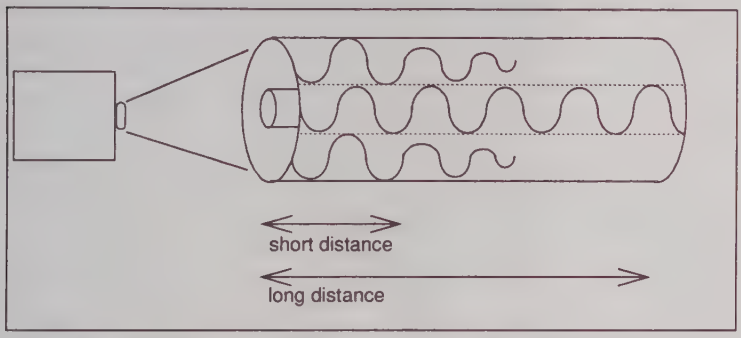

Figure 4-2 Cladding Core Modes with High Numerical Aperture

Due to the internal optics of the IQ-3100 (and the majority of attenuators), most of the cladding modes are filtered out. This means, with the attenuator connected, the power meter will display a loss greater than the attenuation setting of the attenuator (cladding modes have been partially stripped).

Cladding modes are not used in communication systems and, therefore, should not have been part of the source power measurement in the first place. There are several methods of eliminating these cladding modes:

- A cladding mode stripper (preferred method) is a material with a refractive index greater than that of the cladding. With the cladding exposed, the fiber is immersed in the mode stripper (glycerin, oil, or other suitable liquid). Because of the greater refractive index of the stripper, the light energy passes out of the cladding.
- Cladding modes attenuate to insignificant levels over relatively short distances. Use a long fiber jumper.

- A mandrel wrap can be introduced by making a minimum of five turns around a 0.5 in. diameter mandrel. This method will introduce slight losses in the multimode core and remove some of the cladding modes. A mandrel wrap is not the preferred method of controlling cladding modes in multimode fibers.

4.3 IQ-3300 - Bit Error Rate Testing Using Variable Reflector

The variable reflector can be used to determine a network sensitivity to optical reflection. To perform this test, a bit error rate (BER) tester is also required.

1. Connect the IQ-3300 to the network as shown in Figure 4-3.

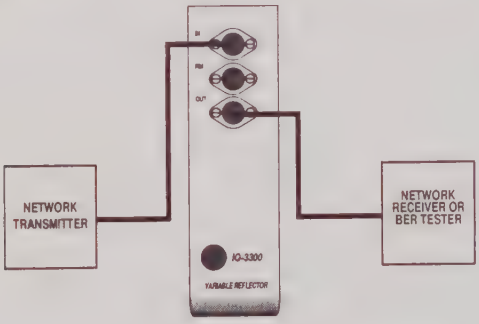

Figure 4-3 Simulation of Network Reflection

2. If desired, a power meter (IQ-1100) may be connected to the monitor port. During the test, this power meter will display the reflected optical power.

3. By varying the reflection and monitoring the error rates, the network sensitivity to reflected power is determined.

4.4 IQ-3300 - Source Stability

Laser output power, power stability, and spectral stability are affected by reflected optical energy. The variable reflector can be used to evaluate these parameters for any fiber-optic laser source or transmitter.

To characterize the source

1. Connect the source under test as shown in Figure 4-4. By integrating a switch into the setup, average power and spectral measurements are easily performed.

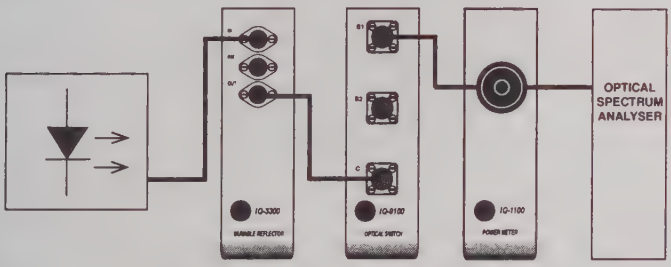

Figure 4-4 Measuring Source Sensitivity to Reflection

2. Vary the IQ-3300 reflection and record the average power and spectral distribution at each reflection step.

This test could be used to determine if the source/transmitter needs to be isolated and if an installed isolator is effective.

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5 MAINTENANCE AND TROUBLESHOOTING

5.1 Maintenance

There are no user-serviceable components in the IQ-3100 and the IQ-3300, notwithstanding the procedure described in this section. The module has been designed to require minimum maintenance and to provide reliable operation for many years to come.

The fiber ends must be kept clean at all times, as explained in Section 2.6, *Optical Connections*, on page 2-16, to ensure minimum loss and reduce reflection.

The optical ports should also be cleaned on a regular basis to ensure optimum performance.

IMPORTANT

When the module is not being used, the protective caps should be fitted over the ports.

To clean the optical ports of the variable reflector

1. Remove the protective caps.
2. Gently wipe the ports with a lint-free swab dipped in isopropyl alcohol.
3. Dry using clean compressed air.

If higher than expected insertion loss is observed, the fiber ends behind the front panel of the module may require cleaning.

To access and clean the pigtails behind the front panel

1. Power OFF the IQ-203/IQ-206.
2. Remove the module from the IQ-203/IQ-206 (see Section 2.7, *Module Removal*, on page 2-17).

3. Remove the four screws as shown in the figure below.

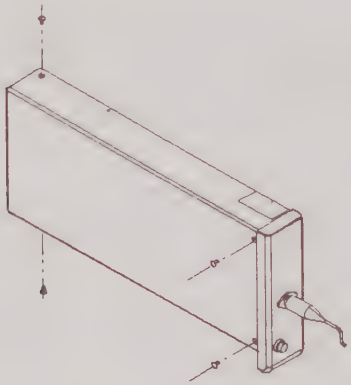

Figure 5-1 Module Screws

4. Slide back the module cover.

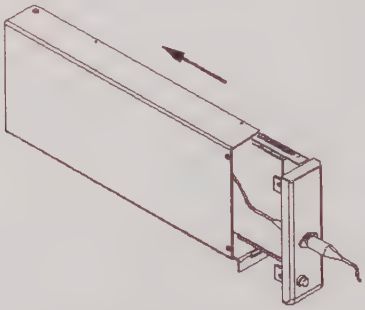

Figure 5-2 Opening the Module

5. The fiber connections should now be accessible. Carefully disconnect the pigtails from the bulkheads inside the module (fully unscrew the connecto before attempting removal and be very careful not to force or damage the pigtails).

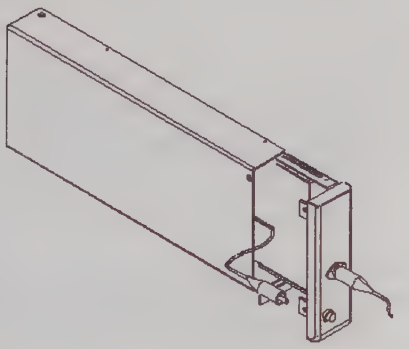

Figure 5-3 Access to Connector for Cleaning

6. Clean the fiber ends using a cleaning pad dipped in isopropyl alcohol (98% pure or more).

7. Blow-dry using clean compressed air.

8. Carefully replace the connectors, slide back the housing, replace the four screws, and reinstall the module.

CAUTION

Be very careful to correctly replace all four screws to avoid damage to module.

The IQ-3200 Return Loss Meter can be used to verify the precision of the input port.

To verify IQ-3300 input port precision using the IQ-3200

1. Connect one end of a test jumper in the input port of the IQ-3200 Return Loss Meter and the other in the IQ-2100 Light Source source port.

2. Connect one end of a second test jumper in the output port of the IQ-3200 and perform a "zero" (see the IQ-3200 manual) at the other end.

3. Connect the unconnected end to the IQ-3300 input port.

4. Activate IQ-3300 shutter.

5. Measured reflection should be -65 dB typical (-60 dB max.), otherwise fiber ends should be cleaned as explained in Section 2.6, *Optical Connections*, on page 2-16.

5.2 Recalibration

To ensure that the module remains within the published specifications, EXFO recommends that an annual calibration is performed. Please contact EXFO for further information regarding calibration of your module.

5.3 Troubleshooting

Problem	Probable Cause	Recommended Action
LED push button does not illuminate.	Power not on.	Check AC power cord and power on the IQ-203 and IQ-206. Refer to IQ-200 manual to verify fuse.
	Module is not properly inserted.	Power OFF the IQ-203 and IQ-206, remove and reinstall the module.
	Computer locked up.	Reboot the IQ-203.
	LED is burnt.	Call EXFO.
Pushing LED push button does not open the module main window.	Computer locked up.	Reboot the IQ-203.
Questionable reflection introduced by the IQ-3300	Dirty optical connectors.	Clean all optical connections.
	Input/output optical path not respected.	Switch input and output connections.
	Improper wavelength selected.	Switch to the correct wavelength on all instruments being used.
	Unstable optical source.	Wait for source to stabilize.

Table 5-1 Problems, Causes, and Recommended Actions

In all cases, if problem persists after performing recommended action, call EXFO.

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6 TECHNICAL SPECIFICATIONS

6.1 IQ-3100 Variable Attenuator

Model	IQ-3100-B	IQ-3100-C	IQ-3100-D	IQ-3100-E
Fiber (μm)	9/125	50/125, 62.5/125, 100/140		
Wavelength Range[1] (nm)	1200 to 1650	700 to 1350		
Spectral Resolution (nm)	0.1			
Attenuation -dB (Max)	>100 (1200-1350 nm) >80 (1350-1600 nm) >70 (1600-1650 nm)	>100 (700-1000 nm) >65 (1000-1350 nm)		
Insertion Loss[2,3] (dB) typical maximum	 1.5 1.8	 1.5 2.0		
Optical Resolution (dB)	0.005	0.01		
Linearity[6] (dB)	+ 0.05			
Absolute Accuracy[3] (dB) typical	± 0.2	± 0.5		
Repeatability (dB) (Max)	< ±0.03			
Return Loss[4] (dB)	≥55	≥25		
Power Handling[5] (dBm)	>25			
PDL (dB) (Max)	< ±0.1			
Shutter Isolation (dB)	>100			

Table 6-1 IQ-3100 Optical Specifications

1. The software performs automatic, wavelength range corrections. Singlemode calibration at 1310 nm and 1550 nm. Multimode calibration at 850 nm and 1300 nm. Correction error of 0.0009 dB/dB/Δnm in singlemode and 0.002 dB/dB/Δnm in multimode where Δnm is the difference between the selected wavelength and the closest calibration wavelength. It is possible to use this correction factor to "tune" the reflector according to the source being used.
2. Calibrated at 1310 nm, 1550 nm for singlemode and 850 nm, 1300 nm for multimode. The insertion loss is dependent on the input numerical aperture.
3. Measured with FC/SPC connectors for singlemode and FC/PC for multimode.
4. The return loss is limited by the return loss of the connectors. The connectors used were APC for singlemode and PC for multimode.

5. Maximum input power above this limit may damage the unit. The linearity may be higher than specified.
6. Obtained at 23 ±2°C using a light source of 0.002 dB stability over a 15 minute period (source precision of ±0.5 nm).

6.2 IQ-3300 Variable Reflector

IQ-3300 Variable Reflector	
Fiber (µm)	9/125
Wavelength Range[1] (nm)	1200 to 1650
Reflection Range (dB)	-15 to -55
Insertion Loss (in-out)[4] (dB)	-5
Resolution (dB)	< 0.01
Accuracy[2] (dB)	± 0.5
Linearity[3] (dB)	< ±0.1
Repeatability (dB)	< ±0.06
Maximum Input Power[5] (dBm)	> 22
PDL (dB)	< ±0.2
Reflection with Shutter (dB)	< -55

Table 6-2 IQ-3300 Optical Specifications

1. The software performs automatic, wavelength range corrections. Singlemode calibration at 1310 nm and 1550 nm. Correction error of 0.002 dB/dB/Δnm in singlemode where Δnm is the difference between the selected wavelength and the closest calibration wavelength. It is possible to use this correction factor to "tune" the reflector according to the source being used.
2. Typical accuracy is measured using APC connectors.
3. Obtained at 23 ±2°C using a light source of 0.002 dB stability over a 15 minute period (source precision of ±0.5 nm).
4. Insertion loss includes connectors.
5. Maximum input power above this limit may damage the unit. The linearity may be higher than specified.

Specifications are subject to change without notice.

Operating Environment	
Operating temperature	32° to 122°F / 0° to +50°C
Storage temperature	-40° to 158°F / -40° to +70°C
Relative humidity[1]	0 to 95% non-condensing

Table 6-3 Operating Environment

1. Measured in 0° to 40°C temperature range.

Mechanical Specifications	
Dimensions	Width: 1.5" / 3.8 cm Height: 4.75" / 12.0 cm Length: 10.3" / 26.2 cm
Weight	1.40 lb / 0.63 kg

Table 6-4 Mechanical Specifications

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7 WARRANTY

7.1 General Information

EXFO E. O. Engineering (EXFO) warrants this equipment against defects in material and workmanship for a period of two years from the date of original shipment. EXFO also warrants that this equipment will meet applicable specifications under normal use.

During the warranty period, EXFO will, at its discretion, repair, replace, or issue credit for any defective product. This warranty also covers recalibration during two years if the equipment is repaired or if the original calibration is erroneous.

IMPORTANT

The warranty can become null and void if

- ***the equipment has been tampered with, repaired, or worked upon by unauthorized individuals or non-EXFO personnel,***
- ***the warranty sticker has been removed,***
- ***case screws, other than those specified in this manual, have been removed,***
- ***the case has been opened, other than as explained in this manual,***
- ***the equipment serial number has been altered, erased, or removed,***
- ***the equipment has been misused, neglected, or damaged by accident.***

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESSED, IMPLIED OR STATUTORY, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL EXFO BE LIABLE FOR SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

7.2 Liability

EXFO shall not be liable for damages resulting from the use of the purchased product, nor shall be responsible for any failure in the performance of other items to which the purchased product is connected or the operation of any system of which the purchased product may be a part.

7.3 Exclusions

EXFO reserves the right to make changes in the design or construction of any of its products at any time without incurring any obligation to make changes whatsoever on units purchased. Accessories, including but not limited to fuses, pilot lamps and batteries used with EXFO's products are not covered by this warranty.

7.4 Certification

EXFO certifies that this equipment met its published specifications at the time of shipment from the factory.

7.5 Service and Repairs

To obtain service or repair for any equipment, follow the procedure below.

1. Call EXFO Sales and Product Support Group. Support personnel will determine if the equipment requires service, repair, or calibration.

2. If the equipment must be returned to EXFO or an authorized service center, support personnel will issue a Return Merchandise Authorization (RMA) and an address for return.

3. Pack the equipment in its original shipping material. Be sure to include a statement or report fully detailing the defect and the conditions under which it was observed.

IMPORTANT

Never send any unit or accessory back to EXFO without a Return Merchandise Authorization (RMA).

4. Return the equipment, prepaid, to the address given by the support personnel. Be sure to write the RMA on the shipping slip. EXFO will refuse and return any package which does not bear an RMA.

Note: *A test setup fee will apply to any returned unit which, after test, is found to meet the applicable specifications.*

5. After repair, the equipment will be returned with a repair report. If the equipment is not under warranty, the customer will be invoiced for the cost appearing on this report. Return-to-customer shipping costs will be paid by EXFO for equipment under warranty. Shipping insurance is at the customer's expense.

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GLOSSARY

AC	Alternating current
adapter	A device for coupling two connectors
amplifier	A device used to boost the strength (dB level) of a signal. Amplifiers are used in broadband networks to overcome the attenuation of transmitted signals.
amplitude	The distance between high and low points of a waveform or signal.
ASCII	American Standard Code for Information Interchange. A system used to represent letters, numbers, symbols, and punctuation as bytes of binary signals.
ASE	Amplified Spontaneous Emission. Light emitted from the decay of the upper level of a lasing transition without stimulated emission. In general, this emission is spectrally broad and unpolarized.
attenuation	The diminution of average optical power. Attenuation results from absorption, scattering, and other radiation losses. Attenuation is generally expressed in dB without a negative sign. Attenuation is often used as a synonym for attenuation coefficient, expressed in dB/km.
attenuation coefficient	A factor expressing optical power loss per unit of length, expressed in dB/km.
attenuator	An optical device, either fixed or adjustable, that reduces the intensity of light propagating through it.
axis of birefringence	One of two generally orthogonal orientations within the fiber corresponding to fast and slow propagation of the group velocity of a light beam. In general, these orientations are elliptical and the orientation and amplitude vary along the fiber. In the special case of a HiBi fiber, the axes are linear and constant along the length of the fiber.

B_{fib}	Fiber bandwidth, normally dependent on carrier wavelength and fiber length.
B_{opt}	Optical bandwidth
backscattering	That portion of scattered light that returns in a direction generally opposite to the direction of propagation.
bandwidth	The range of frequencies handled by a device or system.
baud rate	Measurement of data transmission speed, expressed in bits per second or bps.
beamsplitter	A device for dividing an optical beam into two or more separate beams. It is often a partially reflecting mirror.
beat length	In a reasonably uniform birefringent medium, the distance over which a light wave propagating along the slow axis will accumulate a phase lag of one wavelength (2π) with respect to light propagating along the fast axis. As a rule, the shorter the beat length, the higher the fiber birefringence. Typical HiBi fibers have a beat length of 3 mm at 1550 nm.
Bellcore	Bell communications research, an organization that contains much of the former Bell labs. It specializes in telephone network technology, standards and interfaces.
BER	Bit error rate. On a transmission link, the number of digital "highs" that are interpreted as "lows", and vice versa, divided by the total number of bits received. In modem networks, BERs much better than 10^{-9} are expected.
birefringence	The property whereby the effective propagation speed of a light wave in a medium depends upon the orientation of the electric field (state of polarization) of the light.
c	Velocity of light in a vacuum = 3.998×10^8 km/s
°C	Degree Celsius
center wavelength	For an optical source (e.g. DFB, FP laser, LED), the wavelength corresponding to the weighted average (center of gravity) of the power distribution. Mathematically, $\lambda_c = \frac{\sum \lambda_c P_i}{\sum P_i}$, where P_i is the power of the *ith* constituent of the

	power distribution (e.g. one of the oscillating modes of a Fabry-Perot laser).
CFR	Code of federal regulations
channel	A communication path. For WDM systems, a channel is determined by a wavelength and width.
chromatic dispersion	The speed of an optical pulse travelling in a fiber changes as its wavelength changes. Since any practical light source has a certain spectral width, this effect results in pulse broadening called chromatic dispersion. Chromatic dispersion is determined by the measurement of travel time at different wavelengths.
CNR	Carrier-to-noise ratio
connector	A junction that allows an optical fiber or cable to be repeatedly connected or disconnected to a device such as a source or detector.
core eccentricity	A measure of the displacement of the core center relative to the cladding center.
core ellipticity (non-circularity)	A measure of the departure of the core from roundness.
coupler	A device whose purpose is to distribute optical power among two or more ports or to concentrate optical power from two or more fibers into a single port. Couplers may be active or passive.
coupling ratio	Value obtained by measuring the power at both output ports and providing the output ratio between them. Also, CR.
CPU	Central processing unit
crosstalk	The phenomenon of light leakage or information transmission from a waveguide to one adjacent or from one modulated carrier frequency to another.
cutoff wavelength	For a singlemode fiber, the wavelength above which the fiber can only support the propagation of the lowest order transverse mode.

CW	Abbreviation for continuous wave. Refers to non-modulated, constant-intensity light.
CR	Coupling ratio
dB	Decibel
dBm	Decibel referenced to a milliwatt.
DC	Direct current
decibel (dB)	The standard unit used to express gain or loss of optical power. A standard logarithmic unit for the ratio of two powers.
DFB	Distributed feedback (laser)
diffraction grating	An optical element that causes a wavelength-dependent reflection, often at one or more wavelength-dependent angles. This element is based upon diffraction scattering from an array of fine, parallel, equally spaced reflecting or transmitting lines.
directivity	In a 3-port optical circulator, the ratio of power launched into port 1 that exits via port 2 vs. the fraction that exits via port 3.
distributed feedback laser (DFB)	An injection laser diode that has a Bragg reflection grating in the active region to suppress multiple longitudinal modes and enhance a single-longitudinal mode.
DUT	Device under test
DWDM	Dense wavelength division multiplexing
dynamic range	For an optical instrument, generally defined as the ratio (in dB) of the smallest signal that can be observed (at a specified wavelength separation) in the presence of a strong, nearly saturating signal.
EDFA	Erbium doped fiber amplifier
EIA	Electronics Industries Association
EL	Excess loss

electromagnetic interference	Any electrical or electromagnetic interference that causes degradation, failure in electronic equipment, or undesirable response. Optical fiber neither emit nor receive EMI.
EMI	Electromagnetic interference.
excess loss (EL)	In relation to multiport components, the excess loss is a measure of the insertion loss over and above that induced by the splitting ratio. For example, a coupler with a 3.3-dB insertion loss and 3.0-dB splitting ratio has an excess loss of 0.3 dB.
f	Abbreviation for femto, which indicates 10^{-12} units.
f	Frequency, often also designated by ν.
FCC	Federal Communications Commission. A U.S. government body overseeing and regulating national electrical and radio communications. The FCC, formed in 1934, also deals with licences, tariffs, and limitations. The members of the commission are appointed by the U.S. president.
FP	Fabry-Perot (laser or cavity).
frequency	The number of cycles per unit of time, denoted by Hertz (Hz). 1 Hertz = 1 cycle per second.
Fresnel reflection	Reflection of a portion of the light incident on a planar interface between two homogeneous media having different refractive indices.
FSR	Free Spectral Range. Denotes spacing, in frequency units, between resonant modes of a cavity (e.g FP cavity)
G	Abbreviation for giga, which indicates 10^{9} units.
Ge	Germanium
GeX	High power germanium
HiBi	High birefringence (fiber)
hr	Hour
HWFM	Half wave full maximum

Hz	Hertz
IEC	International Electrotechnical Commission. A standardization body at the same level as ISO.
IEE	U.K. equivalent of the IEEE. It is a professional body covering all aspects of electronics and electrical engineering, including software, network, and computer engineering.
IEEE	Institute of Electrical and Electronics Engineering. The world's largest professional society, based in the United States. It was founded in 1884 by a handful of practitioners of the new electrical engineering discipline. Today's institute has more than 320,000 members in the world and is very active, among other things, in many fiber-optic and opto-electronic related fields.
IL	Insertion loss
index matching material	A material, often a liquid or a cement, whose refractive index is nearly equal to the core index, used to reduce Fresnel reflections from a fiber's endface.
index of refraction	The ratio of the group velocity of a light in a vacuum to the group velocity of light in a given medium.
index profile	The refractive index as a function of radius of an optical fiber.
InGaAs	Indium gallium arsenide, a popular detector material.
insertion loss	The ratio of output power to input power (for a given output port) for an optical component such as a connector, splice, or coupler.
ISO	International Organization for Standardization. Commonly believed to stand for International Standards Organization. In fact, ISO is not an abbreviation—it is intended to signify uniformity (derived from the Greek *iso* meaning "equal"). ISO is responsible for many standards including those for data communications and computing.

ITU	International Telecommunications Union. The ruling body for telecommunications and the source of many network standards.
jumper	Fiber-optic cable that has connectors terminated on both ends. Used to connect two pieces of equipment, modules, or components.
LoBi	Low birefringence (fiber)
LD	Laser diode
LED	Light emitting diode
loopback	Type of diagnostic test in which the transmitted signal is returned to the sending device after passing through a communications link or network.
M	Abbreviation for mega, 10^6 units.
m	Abbreviation for milli, 10^{-3} units.
min	Minute
MFD	Mode field diameter (singlemode fiber).
modal dispersion	Generally used to designate multimode dispersion, which is pulse broadening due to optical power propagating via different waveguide modes. Modal dispersion is the main limitation on the bandwidth of multimode fibers.
mode coupling	The exchange of power among modes.
mode field diameter	The effective diameter of optical energy in a singlemode fiber. Because the mode field diameter is greater than the core diameter, mode field diameter frequently replaces core diameter as a practical parameter.
multiplexing	The process by which two or more signals are transmitted over a single communications channel.
n	Abbreviation for nano, 10^{-9} units.
n_r	Refractive index
NA	Numerical aperture

NBWDM	Narrow band wavelength division multiplexing
NF	Noise figure
NiCd	Nickel cadmium
NiMH	Nickel metal hydride
NIST	National Institute of Standards and Technology. U.S. governmental body that provides the assistance in developing standards. It was formerly the National Bureau of Standards.
numerical aperture (NA)	It is the sine of half the maximum angle of acceptance.
optical channel	An optical wavelength band for wavelength division multiplexing optical communications.
optical rejection ratio	Another commonly used term for "dynamic range" in an optical system.
optical return loss (ORL)	The ratio (expressed in units of dB) of optical power, reflected by a component or an assembly, to the optical power incident on a component or assembly that is introduced into a link or system.
optical time domain reflectometer	A method of characterizing a fiber wherein an optical pulse is transmitted through the fiber and the resulting backscatter and reflections are measured as a function of time and, hence, as a function of distance.
OSA	Optical spectrum analyzer
OTDR	Optical time domain reflectometer
p	Abbreviation for pico, 10^{-12} units
P	Power
PC	In optical schematics, used to designate a polarization controller.
PCS	Plastic-clad silica (fiber)
PDCR	Polarization dependent coupling ratio

PDEL	Polarization dependent excess loss
PDG	Polarization dependent gain
PDL	Polarization dependent loss
polarization controller	Instrument used to control the polarization state of the light. This type of equipment can produce different polarization states of the input light.
polarization dependent loss	A transmission loss that varies with input polarization state. Normally defined as $T_{max}(dB) - T_{min}(dB)$
polarizer	Instrument used to polarize light.
peak wavelength	The wavelength at which the optical power of a source is at maximum.
PMF	Polarization maintaining fiber
polarization mode dispersion (PMD)	Pulse spreading in a singlemode fiber that arises on account of the different group velocities associated with each of the two principal states of polarization of the fiber.
principal states of polarization (PSP)	The two generally orthogonal states of polarization of a monochromatic light beam launched into a fiber (input PSP) that will propagate through the fiber without spreading or distortion. The SOP of this light beam as it exits the fiber will be in one of two, generally orthogonal, output PSPs. In general, the output PSPs are not the same as the input PSPs, and the orientation of these PSPs changes with wavelength. Not to be confused with axes of birefringence. Only in the spectral case of a single HiBi fiber are the PSPs and the axes of birefringence the same.
Rayleigh scattering	Scattering by inhomogeneities in the fiber that are small with respect to wavelength. This scattering mechanism is present in all silica-based fibers. The OTDR principle is based upon the measurement of this backscattering.
RIN	Relative Intensity Noise. A useful measure of the inherent noise of an optical source as a function of frequency (relative to the carrier). Given as a ratio of noise power per

	frequency interval divided by the total power. For a DFB laser, a typical value is -100 dB/Hz at 100 MHz.
RMA	Return merchandise authorization
RNF	Refracted near field
S/N	Signal-to-noise ratio. Also written SNR. The ratio of the received optical power, divided by the noise floor for the optical system.
s	Second
sensitivity	For an optical instrument, the smallest signal that can be detected in the absence of any other signal.
Si	Silicon
SMSR	Side mode suppression ratio
SSE	Source spontaneous emission
state of polarization (SOP)	The distance-dependent orientation of the electric field vector of a propagating optical wave. In general, this vector will trace an ellipse as it propagates. In special cases, it will remain oriented in one direction (linear polarization) or will trace out a circle (left or right circular polarization).
t	Time
T	Abbreviation for tera, 10^{12} units.
V	Volt
VA	Volt-ampere
W	watt
WDM	Wavelength division multiplexing. A technique whereby two or more carrier wavelengths are transmitted over one optical fiber.
wavelength	For monochromatic light, the distance between two successive peaks (or troughs) of the sinusoidally-varying electric-field amplitude. Note that, unlike the case of

frequency, the wavelength of light depends (linearly) on the refractive index of the medium through which it propagates.

XT Crosstalk

λ lambda. Greek letter used to denote wavelength.

μ Abbreviation for micro, 10^{-6} units.

ν nu. Greek letter used to denote frequency. Traditionally, the physics community uses "ν" to denote frequency whereas the engineering community uses "*f*".

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CORPORATE HEADQUARTERS
465 Godin Avenue
Vanier, QC, Canada
G1M 3G7
Tel.: 1-800-663-3936
(418) 683-0211
Fax: (418) 683-2170

info@exfo.com
www.exfo.com

CE

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